PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : E21B 10/16, 10/50	A1	(11) International Publication Number: WO 97/35091 (43) International Publication Date: 25 September 1997 (25.09.97)

(21) International Application Number: PCT/US97/03812

(22) International Filing Date: 12 March 1997 (12.03.97)

(30) Priority Data:
08/628,534 21 March 1996 (21.03.96) US

(71) Applicant: DRESSER INDUSTRIES, INC. [US/US]; 2001 Ross Avenue, Dallas, TX 75201-2916 (US).

(72) Inventors: GUM, Robert, C.; 2702 Red Oak Drive, Grand Prairie, TX 75052 (US). VANDERFORD, William, D.; 1922 Muret, Irving, TX 75062 (US). DENNIS, Thomas, M.; 7519 Basswood Forest, Houston, TX 77095 (US).

(74) Agent: FELGER, Thomas, R.; Baker & Botts, L.L.P., 2001 Ross Avenue, Dallas, TX 75201-2980 (US).

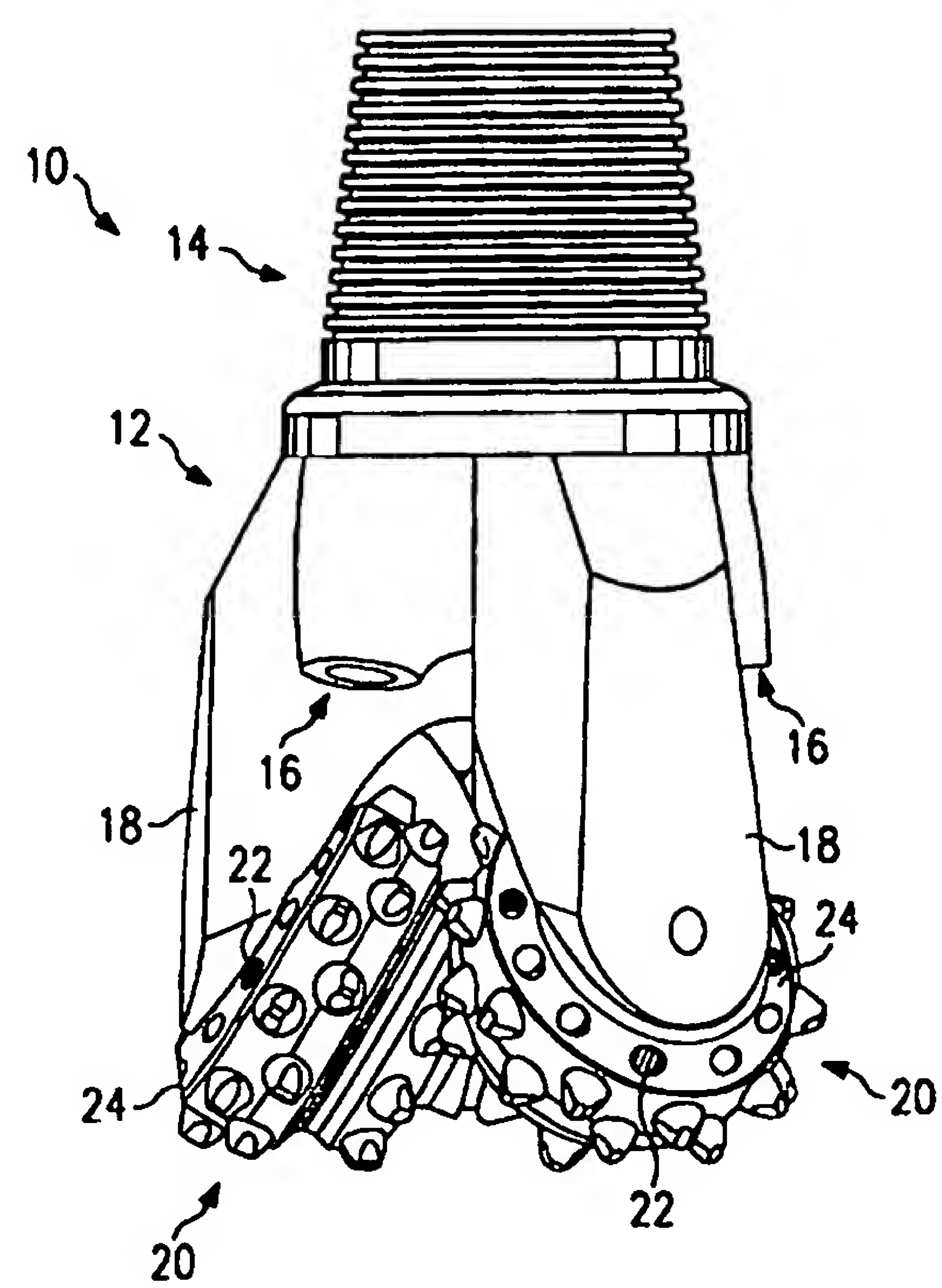
(81) Designated States: CN, GB, MX, SG.

Published
With international search report.

(54) Title: ROLLER CONE GAGE SURFACE CUTTING ELEMENTS WITH MULTIPLE ULTRA HARD CUTTING SURFACES

(57) Abstract

A gage surface cutting element (22, 30, 50, 70, 100, 120) for a cutter (20) in a roller cone drill bit (10) has a generally cylindrical body (32, 52, 72, 102, 122) formed of a hard and wear-resistant material. The cutting end (34, 54, 74, 104, 124) of the cutting element (22, 30, 50, 70, 100, 120) has a generally conical cutting surface (38, 58, 78, 108, 128) substantially perpendicular to a longitudinal axis of the cylindrical body (32, 52, 72, 102, 122). A plurality of generally parallel shallow and elongated grooves (40-42, 60-63, 80-82, 110-112, 130-132) are formed in the conical cutting surface (38, 58, 78, 108, 128), and a plurality of elongated strips of an ultra hard material (44-46, 64-67, 84-86, 114-116, 134-136) is disposed in the grooves. The result is a conical cutting surface (38, 58, 78, 108, 128) that has alternating hard and ultra hard cutting surfaces that can be oriented at 0°, 90°, or any angle in between with respect to the rotational direction of the cutter cone (20).



FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece			TR	Turkey
BG	Bulgaria	HU	Hungary	ML	Mali	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MN	Mongolia	UA	Ukraine
BR	Brazil	IL	Israel	MR	Mauritania	UG	Uganda
BY	Belarus	IS	Iceland	MW	Malawi	US	United States of America
CA	Canada	IT	Italy	MX	Mexico	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NE	Niger	VN	Viet Nam
CG	Congo	KE	Kenya	NL	Netherlands	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NO	Norway	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	NZ	New Zealand		
CM	Cameroon			PL	Poland		
CN	China	KR	Republic of Korea	PT	Portugal		
CU	Cuba	KZ	Kazakstan	RO	Romania		
CZ	Czech Republic	LC	Saint Lucia	RU	Russian Federation		
DE	Germany	LI	Liechtenstein	SD	Sudan		
DK	Denmark	LK	Sri Lanka	SE	Sweden		
EE	Estonia	LR	Liberia	SG	Singapore		

ROLLER CONE GAGE SURFACE CUTTING ELEMENTS WITH MULTIPLE ULTRA HARD CUTTING SURFACES

TECHNICAL FIELD OF THE INVENTION

This invention is related in general to the field of down hole drill bits. More particularly, the invention is related to cutting elements with multiple ultra hard cutting surfaces for the gage surface of a roller cone drill bit.

Square bevel

BACKGROUND OF THE INVENTION

In the field of exploration and production of oil and gas, one type of drill bit or rock bit used for drilling earth boreholes is commonly known as a roller cone drill bit. The typical roller cone drill bit employs a multiplicity of rolling cone cutters rotatably mounted to extend downwardly and inwardly with respect to the central axis of the drill bit. The rolling cone cutters may have milled teeth or cutter inserts disposed on each cutter in predefined patterns.

It has been recognized that it is important in the drilling operation for the drill bit to maintain a consistent borehole diameter. As the drill bit cuts into a rock formation to form a borehole, one portion of each cone cutter, typically called the gage surface, contacts the sidewall of the borehole. Some roller cone drill bits

have been provided wear-resistant and/or ultra hard cutter inserts in the gage surface to cut the sidewall and maintain the diameter of the borehole. The wear-resistant inserts are generally susceptible to heat cracking and spalling during use, and ultra hard cutter inserts are generally prone to frictional heat and chipping damage due to the intense friction between the rock formation and insert. It has also been recognized that flat-tipped inserts may be more prone to damage associated with friction heat, and chisel-tipped inserts may be more prone to breakage.

SUMMARY OF THE INVENTION

Accordingly, there is a need for a gage surface cutting element that produces a reduced amount of frictional heat, is less prone to chipping damage, while maintaining an effective cutting surface.

In accordance with the present invention, a cutting element for the gage surface of a cone cutter is provided which eliminates or substantially reduces the disadvantages associated with prior cutter inserts.

In one aspect of the invention, a gage surface cutting element for a cutter in a roller cone drill bit has a generally cylindrical body formed of a hard and wear-resistant material. The cutting end of the cutting element has a generally conical cutting surface substantially perpendicular to a longitudinal axis of the cylindrical body. The cutting end may additionally include a sloped surface connecting the conical cutting surface and the cylindrical body. The conical cutting surface has an obtuse angle α that may vary between 160° and 180°. A plurality of shallow grooves is formed in the conical cutting surface, and a plurality of strips of an ultra hard material is disposed in the grooves. The number of grooves

and inserts or inlays may range anywhere from one or more, depending on the diameter of the cutting element and the rock formation to be drilled. The result is a conical cutting surface with alternating hard and ultra hard cutting surfaces that can be oriented at 0°, 90°, or any angle in between with respect to the rotational direction of the cutter cone.

In another aspect of the invention, the shallow grooves may be radiused in the conical cutting surface, squared-off in the conical cutting surface, dovetailed in the conical cutting surface, or open-ended toward the conical cutting surface.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the present invention, reference may be made to the accompanying drawings, in which:

FIGURE 1 is an isometric view of a roller cone drill bit having cutting elements constructed according to the present invention installed in the gage surface of the conical cutters;

FIGURE 2 is a top view of a conical cutting surface of a cutting element constructed according to the present invention;

FIGURE 3 is a side view of the cutting element;

FIGURE 4 is another side view of the cutting element;

FIGURE 5 is a top view of another embodiment of a conical cutting surface of a cutting element constructed according to the present invention;

FIGURE 6 is a side view of the cutting element shown in FIGURE 5;

FIGURE 7 is another side view of the cutting element;

FIGURE 8 is a top view of another embodiment of a conical cutting surface of a cutting element constructed according to the present invention;

FIGURE 9 is a side view of the cutting element shown in FIGURE 8;

FIGURE 10 is a top view of another embodiment of a conical cutting surface of a cutting element constructed according to the present invention;

FIGURE 11 is a side view of the cutting element shown in FIGURE 10;

FIGURE 12 is a top view of another embodiment of a conical cutting surface of a cutting element constructed according to the present invention;

FIGURE 13 is a side view of the cutting element shown in FIGURE 12;

FIGURE 14 is a cross-sectional view of the cutting element shown in FIGURE 2;

FIGURE 15 is a side view of an embodiment of a groove configuration according to the present invention;

FIGURE 16 is a side view of another embodiment of a groove configuration according to the present invention;

FIGURE 17 is a side view of another embodiment of a groove configuration according to the present invention;

FIGURE 18 is a side view of another embodiment of a groove configuration according to the present invention; and

FIGURES 19A and 19B are views of the gage surface of the conical cutter to demonstrate the orientation of the cutting element with respect to the direction of rotation.

DETAILED DESCRIPTION OF THE INVENTION

The preferred embodiments of the present invention are illustrated in FIGURES 1-19, like reference numerals being

used to refer to like and corresponding parts of the various drawings.

For purposes of illustration, the present invention is shown embodied in a roller cone drill bit 10 used in drilling a borehole in the earth, as shown in FIGURE 1. Roller cone drill bit 10 may also be referred to as a "rotary drill bit" or "rock bit." Roller cone drill bit 10 preferably includes a bit body 12 with an upper threaded portion or pin 14 adapted for attaching to the lower end of a drill string (not shown). Threaded portion 14 and the corresponding threaded connection of the drill string allow for the rotation of drill bit 10 in response to the rotation of the drill string at the well surface. Bit body 12 includes an inner passage (not shown) that permits cool drilling mud or like material to pass downward from the drill string. The drilling mud exits through nozzles 16 (two are shown), flows downward to the bottom of the borehole and then passes upward in the annulus between the wall of the borehole and the drill string, carrying drilling debris and rock chips therewith.

In the tri-cone roller cone drill bit 10, three substantially identical arms 18 (two are shown) depend from bit body 12. Each arm 18 rotatably supports a conical cutter assembly 20, and each conical cutter assembly 20 has a plurality of cutter inserts or milled teeth arranged in a predetermined manner thereon. The present invention is directed to cutter inserts or cutting elements 22 disposed in a gage surface 24 located on cutter assembly 20. Cutter inserts 22 make up a surf row of the cutter assembly 20 and is defined as the portion of the cutter assembly 20 which contacts the outermost periphery or sidewall of the borehole (not shown) as drill bit 10 is rotatably cutting the borehole. The surf row is also commonly called a gage

row in the industry and will be referred to as such hereinafter.

Referring to FIGURES 2-4, a cutter insert 30 constructed according to the teachings of the present invention is shown. Cutter insert 30 includes a generally cylindrical body 32 or substrate constructed from a hard and wear-resistant material such as cemented tungsten carbide. Cutter insert body 32 has a cutting end 34 and a base 36 which is press fit into sockets formed in gage surface 24 of conical cutter assembly 20. Cutting end 34 defines a generally conical cutting surface 38, which extends slightly above the gage surface 24 to contact the borehole. Conical cutting surface 38 has an obtuse angle α that may vary between 160° and 180°.

Formed in conical cutting surface 38 of cutting element 30 is a plurality of shallow grooves 40-42 extending generally parallel with one another. Inlaid into these grooves 40-42 are elongated strips or inserts 44-46 made from an ultra hard and abrasion-resistant material, such as diamond, polycrystalline diamond, thermally stable polycrystalline diamond (TSP), cubic boron nitride or other non-diamond material that is ultra hard and abrasion-resistant. Elongated inserts 44-46 are manufactured and shaped to conform to grooves 40-42 to ensure a secure fit. Elongated ultra hard inserts 44-46 may be secured in grooves 40-42 by sintering, brazing, interference fit, or other like methods. Constructed in this manner, conical cutting surface 38 is defined by both hard and ultra hard materials. Cutting end 34 may additionally include a sloped surface 48 connecting conical cutting surface 38 and cylindrical body 32. The sloped surface 48 may be chamfered, radiused, beveled, or similarly inclined.

Referring to FIGURES 5-7, another embodiment of a cutter insert 50 is shown. Cutter insert 50 includes a

generally cylindrical body 52 also constructed from a hard and wear-resistant material such as cemented tungsten carbide. Cutter insert body 52 includes a cutting end 54 and a base 56. Cutting end 54 defines a generally conical cutting surface 58, which extends slightly above the gage surface 24 when mounted therein. Conical cutting surface 58 has an obtuse angle α between 160° and 180°.

Formed in conical cutting surface 58 of cutting element 50 is a plurality of shallow grooves 60-63 extending generally parallel with one another. Filling in these grooves 60-63 are elongated strips or inserts 64-67 made from an ultra hard and abrasion-resistant material, such as diamond, polycrystalline diamond, thermally stable polycrystalline diamond (TSP), cubic boron nitride or other non-diamond material that is ultra hard and abrasion-resistant. Elongated inserts 64-67 are manufactured and shaped to conform to grooves 60-63 to ensure a secure fit. Elongated ultra hard inserts 64-67 may be secured in grooves 60-63 by sintering, brazing, interference fit, or other methods. Cutting end 54 may also include a sloped surface 68 connecting conical cutting surface 58 and cylindrical body 52. The sloped surface 68 may be chamfered, radiused, beveled, or similarly inclined.

Referring to FIGURES 8-9, another embodiment of a cutter insert 70 is shown. Cutter insert 70 includes a generally cylindrical body 72 constructed from a hard and wear-resistant material such as cemented tungsten carbide. Cutter insert body 72 includes a cutting end 74 and a base 76. Cutting end 74 defines a generally conical cutting surface 78, which extends slightly above the gage surface 24 when mounted therein. Conical cutting surface 78 has an obtuse angle α between 160° and 180°.

Formed in conical cutting surface 78 of cutting element 70 is a plurality of circular shallow grooves 80-82

extending generally concentric with one another. Filling in these grooves 80-82 are circular strips or inserts 84-86 made from an ultra hard and abrasion-resistant material, such as diamond, polycrystalline diamond, thermally stable polycrystalline diamond (TSP), cubic boron nitride or other non-diamond material that is ultra hard and abrasion-resistant. Elongated inserts 84-86 are manufactured and shaped to conform to grooves 80-82 to ensure a secure fit. Elongated ultra hard inserts 84-86 may be secured in grooves 80-82 by sintering, brazing, interference fit, or other methods. Cutting end 74 may also include a sloped surface 88 connecting conical cutting surface 78 and cylindrical body 72. The sloped surface 88 may be chamfered, radiused, beveled, or similarly inclined.

Referring to FIGURES 10-11, another embodiment of a cutter insert 100 is shown. Cutter insert 100 includes a generally cylindrical body 102 constructed from a hard and wear-resistant material such as cemented tungsten carbide. Cutter insert body 102 includes a cutting end 104 and a base 106. Cutting end 104 defines a generally conical cutting surface 108, which extends slightly above the gage surface 24 when mounted therein. Conical cutting surface 108 has an obtuse angle α between 160° and 180°.

Formed in conical cutting surface 108 of cutting element 100 is a plurality of curved shallow grooves 110-112 extending generally in equal spaced relation with one another. Filling in these grooves 110-112 are elongated curved strips or inserts 114-116 made from an ultra hard and abrasion-resistant material, such as diamond, polycrystalline diamond, thermally stable polycrystalline diamond (TSP), cubic boron nitride or other non-diamond material that is ultra hard and abrasion-resistant. Elongated inserts 114-116 are manufactured and shaped to conform to grooves 110-112 to ensure a secure fit.

Elongated ultra hard inserts 114-116 may be secured in grooves 110-112 by sintering, brazing, interference fit, or other methods. Cutting end 104 may also include a sloped surface 118 connecting conical cutting surface 108 and cylindrical body 102. The sloped surface 118 may be chamfered, radiused, beveled, or similarly inclined.

Referring to FIGURES 12-13, another embodiment of a cutter insert 120 is shown. Cutter insert 120 includes a generally cylindrical body 122 constructed from a hard and wear-resistant material such as cemented tungsten carbide. Cutter insert body 122 includes a cutting end 124 and a base 126. Cutting end 124 defines a generally conical cutting surface 128, which extends slightly above the gage surface 24 when mounted therein. Conical cutting surface 128 has an obtuse angle α between 160° and 180°.

Formed in conical cutting surface 128 of cutting element 120 is a plurality of rectangular shallow grooves 130-132 extending generally parallel with one another in a staggered pattern. Filling in these grooves 130-132 are rectangular strips or inserts 134-136 made from an ultra hard and abrasion-resistant material, such as diamond, polycrystalline diamond, thermally stable polycrystalline diamond (TSP), cubic boron nitride or other non-diamond material that is ultra hard and abrasion-resistant. Rectangular inserts 134-136 are manufactured and shaped to conform to grooves 130-132 to ensure a secure fit. Rectangular ultra hard inserts 134-136 may be secured in grooves 130-132 by sintering, brazing, interference fit, or other methods. Cutting end 124 may also include a sloped surface 138 connecting conical cutting surface 128 and cylindrical body 122. The sloped surface 138 may be chamfered, radiused, beveled, or similarly inclined.

Referring now to FIGURE 14, a cross-section of a cutting element is shown. Although FIGURE 14 particularly

shows cutting element 30 of FIGURE 2, it is equally applicable to cutting element 50 of FIGURE 5, cutting element 70 of FIGURE 8, cutting element 100 of FIGURE 10, and cutting element 120 of FIGURE 12.

In FIGURE 14, the thickness or depth of ultra hard material 45 near the center of insert 30, δ_C , and near the periphery, δ_P, are specifically shown. It is contemplated that the thickness of ultra hard material 45 and thus the depth of shallow groove 41 need not be the same and may vary gradually. Therefore, δ_C may be greater or less than δ_P if desired depending on the rock formation and application. In particular, δ_P may be greater than δ_C because the edges experience more friction and more wearing than the center of the cutting surface. Note that the variation in ultra hard material thickness may be present in all elongated inserts in a cutting element or it may be present in selected inserts.

Referring now to FIGURES 15-18, the configuration of the groove may be varied to improve endurance of the cutter element. FIGURE 15 shows an embodiment of a groove configuration for cutter element 30. Although FIGURE 15 particularly shows cutting element 30 of FIGURE 2, it is equally applicable to cutting element 50 of FIGURE 5, cutting element 70 of FIGURE 8, cutting element 100 of FIGURE 10, and cutting element 120 of FIGURE 12.

As shown by FIGURE 15, grooves 40-42 are radiused in conical cutting surface 38 of cutting element 30. Elongated inserts 44-46 are manufactured and shaped to conform to the radiused grooves 40-42. Accordingly, the bulk of the ultra hard and abrasion-resistant material forming inserts 44-46 is provided at or near the conical cutting surface 38. As a result, the cutting element 30 has an increased cutting ability at the beginning of its

life that exponentially decreases with wear to the element 30.

Referring now to FIGURE 16, another embodiment of a groove configuration for cutter element 30 is shown. Although FIGURE 16 particularly shows cutting element 30 of FIGURE 2, it is equally applicable to cutting element 50 of FIGURE 5, cutting element 70 of FIGURE 8, cutting element 100 of FIGURE 10, and cutting element 120 of FIGURE 12.

As shown by FIGURE 16, grooves 40-42 are squared-off in conical cutting surface 38 of cutting element 30. Elongated inserts 44-46 are manufactured and shaped to conform to the rectangular grooves 40-42. Accordingly, the ultra hard and abrasion-resistant material forming inserts 44-46 is evenly distributed throughout the inserts. As a result, the cutting element 30 has a uniform cutting ability over its life.

Referring now to FIGURE 17, another embodiment of a groove configuration for cutter element 30 is shown. Although FIGURE 17 particularly shows cutting element 30 of FIGURE 2, it is equally applicable to cutting element 50 of FIGURE 5, cutting element 70 of FIGURE 8, cutting element 100 of FIGURE 10, and cutting element 120 of FIGURE 12.

As shown by FIGURE 17, grooves 40-42 are dovetailed in conical cutting surface 38 of cutting element 30. Elongated inserts 44-46 are manufactured and shaped to conform to the dovetailed grooves 40-42. Accordingly, the bulk of the ultra hard and abrasion-resistant material forming inserts 44-46 is provided below the conical cutting surface 38. As a result, the cutting element 30 has a decreased cutting ability at the beginning of its life that exponentially increases with wear to the element 30. Moreover, the dovetailed grooves 40-42 provide increased retention by the cutting element for the inserts 44-46. As

a result, the inserts tend to wear down past the point where they would break off in other configurations.

Referring now to FIGURE 18, another embodiment of a groove configuration for cutter element 30 is shown. Although FIGURE 18 particularly shows cutting element 30 of FIGURE 2, it is equally applicable to cutting element 50 of FIGURE 5, cutting element 70 of FIGURE 8, cutting element 100 of FIGURE 10, and cutting element 120 of FIGURE 12.

As shown by FIGURE 18, grooves 40-42 are open-ended toward the conical cutting surface 38 of cutting element 30. Elongated inserts 44-46 are manufactured and shaped to conform to the open-ended grooves 40-42. Accordingly, the bulk of the ultra hard and abrasion-resistant material forming inserts 44-46 is provided at or near the conical cutting surface 38. As a result, the cutting element 30 has an increased cutting ability at the beginning of its life that exponentially decreases with wear to the element 30.

Referring to FIGURES 19A and 19B, a partial view of roller cone cutter 20 is shown as seen from the base thereof. Cutter 20 includes gage surface 24 in which a row of cutting elements is mounted, including cutting elements 22 constructed in accordance with the teachings of the present invention. Cutter 20 rotates about a center axis 70 in the direction of rotation as indicated.

In FIGURE 19A, cutting elements 22 are mounted in the gage row such that the ultra hard inserts are generally perpendicular to the direction of rotation. In other words, the axis of the ultra hard inserts is at 90° to the direction of cone rotation. When mounted in this manner, a plurality of successive cutting surfaces formed by alternating hard and ultra hard materials are presented to the rock formation in the sidewall of the borehole. The hard material acts to protect the ultra hard inserts from

chipping damage caused by over exposure of the ultra hard material to the sidewall of the borehole. Depending on the position of ultra hard inserts, the leading edge or cutting surface may be the hard or ultra hard material. As the leading edge wears away, the next cutting surface presents a new cutting edge and surface to continuously cut a full diameter borehole.

In FIGURE 19B, the axis of ultra hard inserts in cutting elements 22 are oriented generally parallel with respect to the direction of cone rotation. In other words, the ultra hard inserts are at 0° to the direction of rotation. The resulting cutting action is rake or claw-like. The interruption of the ultra hard cutting surface by the hard cutting surface as the leading edge of the cutting surfaces is presented to the rock formation results in less friction and more efficient cutting.

It may be seen that cutting element 22 constructed according to the present invention may populate all sockets in the gage row or selected sockets therein depending on the application and rock formation.

Although the present invention and its advantages have been described in detail, it should be understood that various changes, substitutions and alterations can be made therein without departing from the spirit and scope of the invention as defined by the appended claims.

WHAT IS CLAIMED IS:

1. A gage surface cutting element for a cutter in a roller cone drill bit, comprising:

a generally cylindrical body formed of a hard and wear-resistant material and having a cutting end, said cutting end having a generally conical cutting surface substantially perpendicular to a longitudinal axis of said cylindrical body;

a plurality of shallow grooves formed in said conical cutting surface;

a plurality of strips of an ultra hard material having a shape and profile conforming to said shallow grooves, said strips defining cutting surfaces substantially in line with said conical cutting surface; and

said hard and wear-resistant material and said ultra hard material defining a plurality of alternating hard and ultra hard elongated cutting surfaces and a small angle of approach with respect to a sidewall of a borehole.

2. The gage surface cutting element, as set forth in claim 1, wherein said conical cutting surface has an angle between 160° and 180°.

3. The gage surface cutting element, as set forth in claim 1, wherein a plurality of the cutting elements are interference fitted into sockets formed in the gage surface of the cutter, the cutting elements being oriented so that a plurality of alternating hard and ultra hard cutting surfaces are defined generally perpendicular to the direction of cutter rotation.

4. The gage surface cutting element, as set forth in claim 3, wherein said plurality of alternating hard and ultra hard cutting surfaces wear successively to continuously present a new cutting surface to cut and maintain a full diameter bore hole.

5. The gage surface cutting element, as set forth in claim 4, wherein a leading cutting surface is of the hard material.

6. The gage surface cutting element, as set forth in claim 4, wherein a leading cutting surface is of the ultra hard material.

7. The gage surface cutting element, as set forth in claim 1, wherein a plurality of the cutting elements are interference fitted into sockets formed in the gage surface of the cutter, the cutting elements being oriented so that a plurality of alternating hard and ultra hard cutting surfaces are generally defined parallel with the direction of cutter rotation.

8. The gage surface cutting element, as set forth in claim 7, wherein said plurality of alternating hard and ultra hard cutting surfaces cut and maintain a full diameter bore hole with a claw-like cutting action.

9. The gage surface cutting element, as set forth in claim 1, wherein a plurality of the cutting elements are interference fitted into sockets formed in the gage surface of the cutter, the cutting elements being oriented so that an axis of said plurality of strips of ultra hard material is oriented at an angle between 0° to 90°, inclusively, to the direction of cutter rotation.

10. The gage surface cutting element, as set forth in claim 1, wherein said shallow grooves and strips of ultra hard material extend substantially to a periphery edge of said conical cutting surface.

11. The gage surface cutting element, as set forth in claim 1, further comprising a sloped surface coupling said conical cutting surface and said cylindrical body.

12. The gage surface cutting element, as set forth in claim 1, wherein at least one of said plurality of shallow grooves has varying depth along its length.

13. The gage surface cutting element, as set forth in claim 1, wherein said plurality of shallow grooves are deeper near a center of said conical cutting surface than near a periphery edge of said conical cutting surface.

14. The gage surface cutting element, as set forth in claim 1, wherein said plurality of shallow grooves are shallower near a center of said conical cutting surface than near a periphery edge of said conical cutting surface.

15. The gage surface cutting element, as set forth in claim 1, wherein said plurality of shallow grooves are elongated and generally parallel with one another.

16. The gage surface cutting element, as set forth in claim 15, wherein said plurality of shallow grooves are radiused in said conical cutting surface.

17. The gage surface cutting element, as set forth in claim 15, wherein said plurality of shallow grooves are squared-off in said conical cutting surface.

18. The gage surface cutting element, as set forth in claim 15, wherein said plurality of shallow grooves are dovetailed in said conical cutting surface.

19. The gage surface cutting element, as set forth in claim 15, wherein said plurality of shallow grooves are open-ended toward said conical cutting surface.

20. The gage surface cutting element, as set forth in claim 1, wherein said plurality of shallow grooves are circular and generally concentric with one another.

21. The gage surface cutting element, as set forth in claim 20, wherein said plurality of shallow grooves are radiused in said conical cutting surface.

22. The gage surface cutting element, as set forth in claim 20, wherein said plurality of shallow grooves are squared-off in said conical cutting surface.

23. The gage surface cutting element, as set forth in claim 20, wherein said plurality of shallow grooves are dovetailed in said conical cutting surface.

24. The gage surface cutting element, as set forth in claim 20, wherein said plurality of shallow grooves are open-ended toward said conical cutting surface.

25. The gage surface cutting element, as set forth in claim 1, wherein said plurality of shallow grooves are curved and generally in equally spaced relation with one another.

26. The gage surface cutting element, as set forth in claim 25, wherein said plurality of shallow grooves are radiused in said conical cutting surface.

27. The gage surface cutting element, as set forth in claim 25, wherein said plurality of shallow grooves are squared-off in said conical cutting surface.

28. The gage surface cutting element, as set forth in claim 25, wherein said plurality of shallow grooves are dovetailed in said conical cutting surface.

29. The gage surface cutting element, as set forth in claim 25, wherein said plurality of shallow grooves are open-ended toward said conical cutting surface.

30. The gage surface cutting element, as set forth in claim 1, wherein said plurality of shallow grooves are generally parallel with one another and arranged in a staggered pattern.

31. The gage surface cutting element, as set forth in claim 30, wherein said plurality of shallow grooves are radiused in said conical cutting surface.

32. The gage surface cutting element, as set forth in claim 30, wherein said plurality of shallow grooves are squared-off in said conical cutting surface.

33. The gage surface cutting element, as set forth in claim 30, wherein said plurality of shallow grooves are dovetailed in said conical cutting surface.

34. The gage surface cutting element, as set forth in claim 30, wherein said plurality of shallow grooves are open-ended toward said conical cutting surface.

35. The gage surface cutting element, as set forth in claim 1, wherein said plurality of shallow grooves are radiused in said conical cutting surface.

36. The gage surface cutting element, as set forth in claim 1, wherein said plurality of shallow grooves are squared-off in said conical cutting surface.

37. The gage surface cutting element, as set forth in claim 1, wherein said plurality of shallow grooves are dovetailed in said conical cutting surface.

38. The gage surface cutting element, as set forth in claim 1, wherein said plurality of shallow grooves are open-ended toward said conical cutting surface.

39. The gage surface cutting element, as set forth in claim 1, wherein said wear-resistant hard material is cemented tungsten carbide and said ultra hard material is polycrystalline diamond.

40. The gage surface cutting element, as set forth in claim 1, wherein the cutting element is interference fitted into a socket so that said conical cutting surface is generally above the gage surface.

41. In a roller cone drill bit having a gage surface contacting a sidewall of a borehole during operations, said gage surface having at least one row of cutter inserts, at least one of said cutter inserts comprising:

a generally cylindrical substrate formed of cemented carbide and having a cutting end, said cutting end having a generally conical cutting surface substantially normal to a longitudinal axis of said cylindrical substrate;

a plurality of shallow grooves formed in said conical cutting surface;

a plurality of strips of polycrystalline diamond having a shape and profile conforming to said shallow grooves, said polycrystalline diamond strips defining cutting surfaces substantially in line with said conical cutting surface defined by said cemented carbide substrate; and

said conical cutting surface defined by said cemented carbide substrate and said polycrystalline diamond strips forming a plurality of alternating hard and ultra hard elongated cutting surfaces and a small angle of approach with respect to the sidewall of the borehole.

42. The cutter insert, as set forth in claim 41, wherein said conical cutting surface has an angle between 160° and 180°.

43. The cutter insert, as set forth in claim 41, wherein a plurality of the cutter inserts are interference fitted into sockets formed in the gage surface of the cutter, the cutter inserts being oriented so that a plurality of alternating hard and ultra hard cutting surfaces are defined generally perpendicular to the direction of cutter rotation.

44. The cutter insert, as set forth in claim 43, wherein said plurality of alternating hard and ultra hard cutting surfaces wear successively to continuously present a new cutting surface to cut and maintain a full diameter bore hole.

45. The cutter insert, as set forth in claim 44, wherein a leading cutting surface material is cemented carbide.

46. The cutter insert, as set forth in claim 44, wherein a leading cutting surface material is polycrystalline diamond.

47. The cutter insert, as set forth in claim 41, wherein a plurality of the cutter inserts are interference fitted into sockets formed in the gage surface of the cutter, the cutter inserts being oriented so that a plurality of alternating hard and ultra hard cutting surfaces are generally defined parallel with the direction of cutter rotation.

48. The cutter insert, as set forth in claim 47, wherein said plurality of alternating hard and ultra hard cutting surfaces cut and maintain a full diameter bore hole with a claw-like cutting action.

49. The cutter insert, as set forth in claim 41, wherein a plurality of the cutter inserts are interference fitted into sockets formed in the gage surface of the cutter, the cutter inserts being oriented so that an axis of said plurality of polycrystalline diamond strips is oriented at an angle between 0° to 90°, inclusively, to the direction of cutter rotation.

50. The cutter insert, as set forth in claim 41, wherein said shallow grooves and strips of polycrystalline diamond extend substantially to a periphery edge of said conical cutting surface.

51. The cutter insert, as set forth in claim 41, further comprising a sloped surface coupling said conical cutting surface and said cylindrical substrate.

52. The cutter insert, as set forth in claim 41, wherein at least one of said plurality of shallow grooves has varying depth along its length.

53. The cutter insert, as set forth in claim 41, wherein said plurality of shallow grooves are deeper near a center of said conical cutting surface than near a periphery edge of said conical cutting surface.

54. The cutter insert, as set forth in claim 41, wherein said plurality of shallow grooves are shallower near a center of said conical cutting surface than near a periphery edge of said conical cutting surface.

55. The cutter insert, as set forth in claim 41, wherein said plurality of shallow grooves are elongated and generally parallel with one another.

56. The cutter insert, as set forth in claim 55, wherein said plurality of shallow grooves are radiused in said conical cutting surface.

57. The cutter insert, as set forth in claim 55, wherein said plurality of shallow grooves are squared-off in said conical cutting surface.

58. The cutter insert, as set forth in claim 55, wherein said plurality of shallow grooves are dovetailed in said conical cutting surface.

59. The cutter insert, as set forth in claim 55, wherein said plurality of shallow grooves are open-ended toward said conical cutting surface.

60. The cutter insert, as set forth in claim 41, wherein said plurality of shallow grooves are circular and generally concentric with one another.

61. The cutter insert, as set forth in claim 60, wherein said plurality of shallow grooves are radiused in said conical cutting surface.

62. The cutter insert, as set forth in claim 60, wherein said plurality of shallow grooves are squared-off in said conical cutting surface.

63. The cutter insert, as set forth in claim 60, wherein said plurality of shallow grooves are dovetailed in said conical cutting surface.

64. The cutter insert, as set forth in claim 60, wherein said plurality of shallow grooves are open-ended toward said conical cutting surface.

65. The cutter insert, as set forth in claim 41, wherein said plurality of shallow grooves are curved and generally in equally spaced relation with one another.

66. The cutter insert, as set forth in claim 65, wherein said plurality of shallow grooves are radiused in said conical cutting surface.

67. The cutter insert, as set forth in claim 65, wherein said plurality of shallow grooves are squared-off in said conical cutting surface.

68. The cutter insert, as set forth in claim 65, wherein said plurality of shallow grooves are dovetailed in said conical cutting surface.

69. The cutter insert, as set forth in claim 65, wherein said plurality of shallow grooves are open-ended toward said conical cutting surface.

70. The cutter insert, as set forth in claim 41, wherein said plurality of shallow grooves are generally parallel with one another and arranged in a staggered pattern.

71. The cutter insert, as set forth in claim 70, wherein said plurality of shallow grooves are radiused in said conical cutting surface.

72. The cutter insert, as set forth in claim 70, wherein said plurality of shallow grooves are squared-off in said conical cutting surface.

73. The cutter insert, as set forth in claim 70, wherein said plurality of shallow grooves are dovetailed in said conical cutting surface.

74. The cutter insert, as set forth in claim 70, wherein said plurality of shallow grooves are open-ended toward said conical cutting surface.

75. The cutter insert, as set forth in claim 41, wherein said plurality of shallow grooves are radiused in said conical cutting surface.

76. The cutter insert, as set forth in claim 41, wherein said plurality of shallow grooves are squared-off in said conical cutting surface.

77. The cutter insert, as set forth in claim 41, wherein said plurality of shallow grooves are dovetailed in said conical cutting surface.

78. The cutter insert, as set forth in claim 41, wherein said plurality of shallow grooves are open-ended toward said conical cutting surface.

79. A roller cone drill bit having a conical cutter assembly with an improved gage surface cutting element for actively cutting a sidewall of a borehole, comprising:

a generally cylindrical body formed of a hard and wear-resistant material and having a cutting end, said cutting end having a generally conical cutting surface having an angle between 160° and 180°, said conical cutting surface being substantially perpendicular to a longitudinal axis of said cylindrical body;

a plurality of shallow grooves formed in said conical cutting surface;

a plurality of strips of an ultra hard material having a shape and profile conforming to said shallow grooves, said strips defining cutting surfaces substantially in line with said conical cutting surface; and

said hard and wear-resistant material and said ultra hard material defining a plurality of alternating hard and ultra hard cutting surfaces and a small angle of approach with respect to the sidewall of the borehole.

FIG. 1

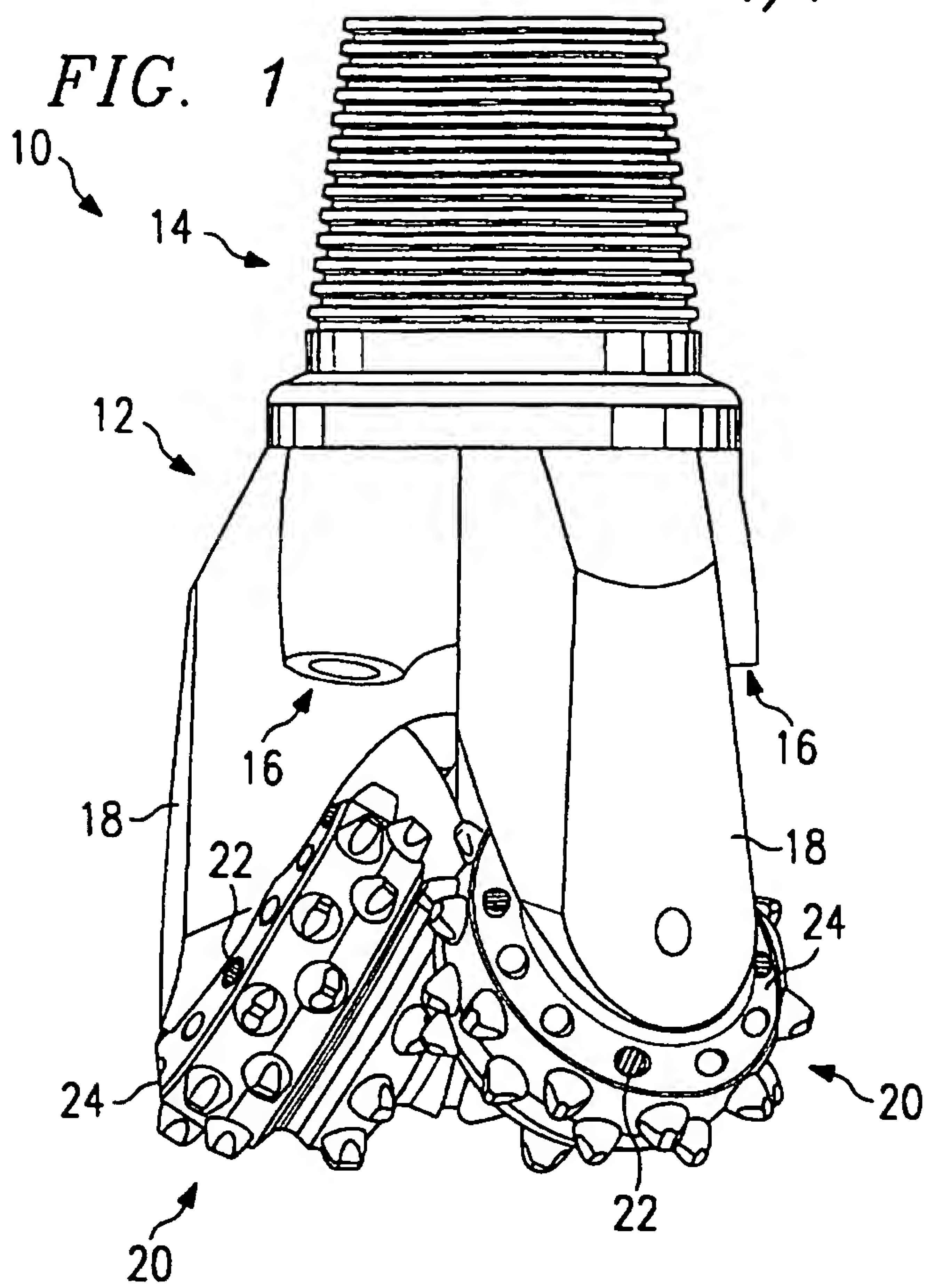


FIG. 2

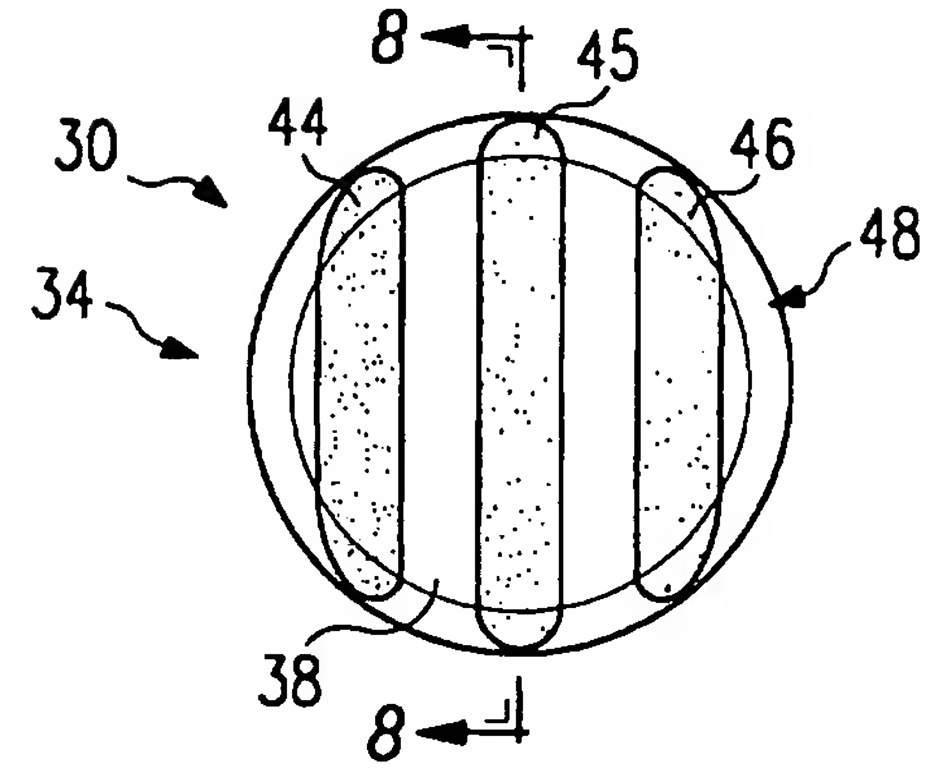


FIG. 3

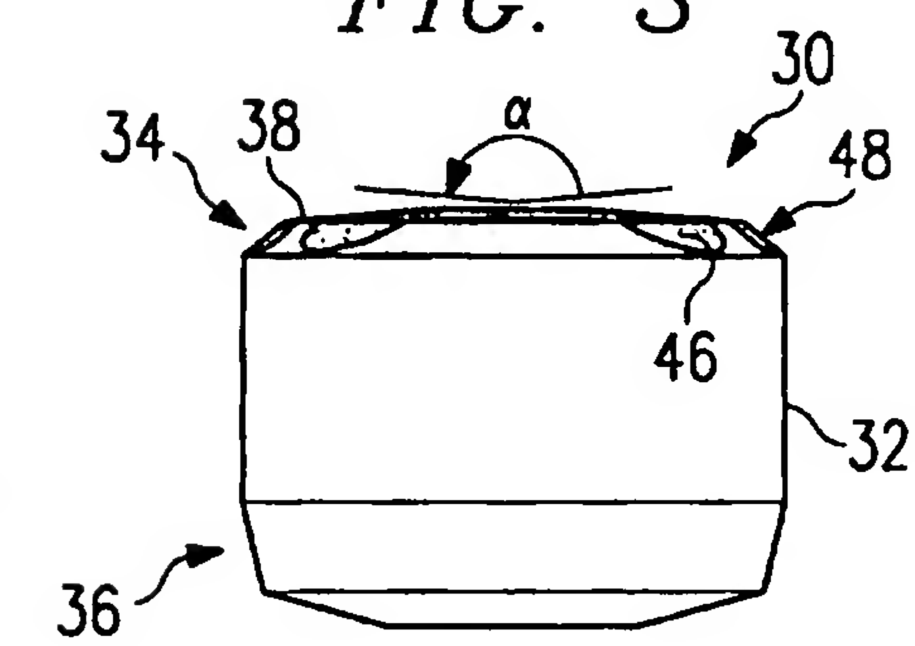


FIG. 5

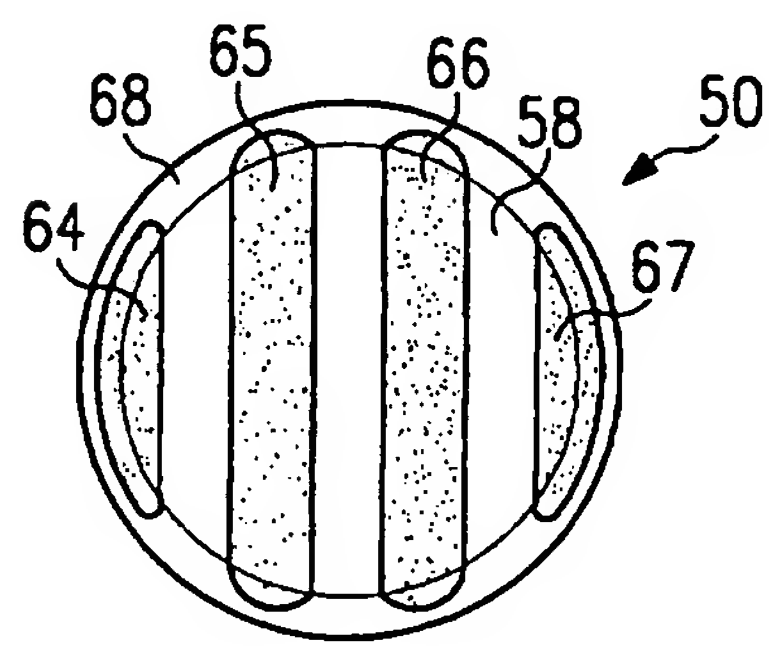


FIG. 4

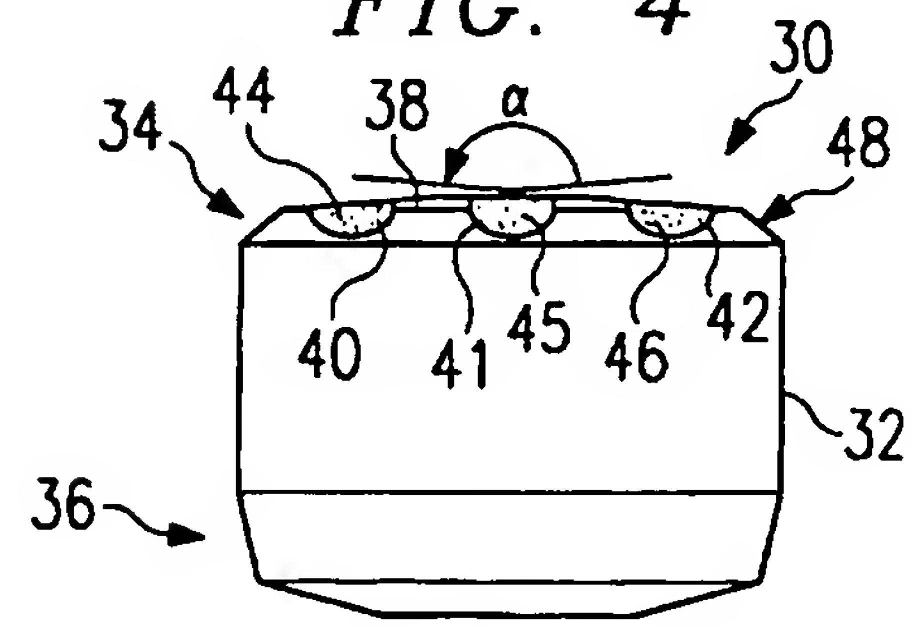
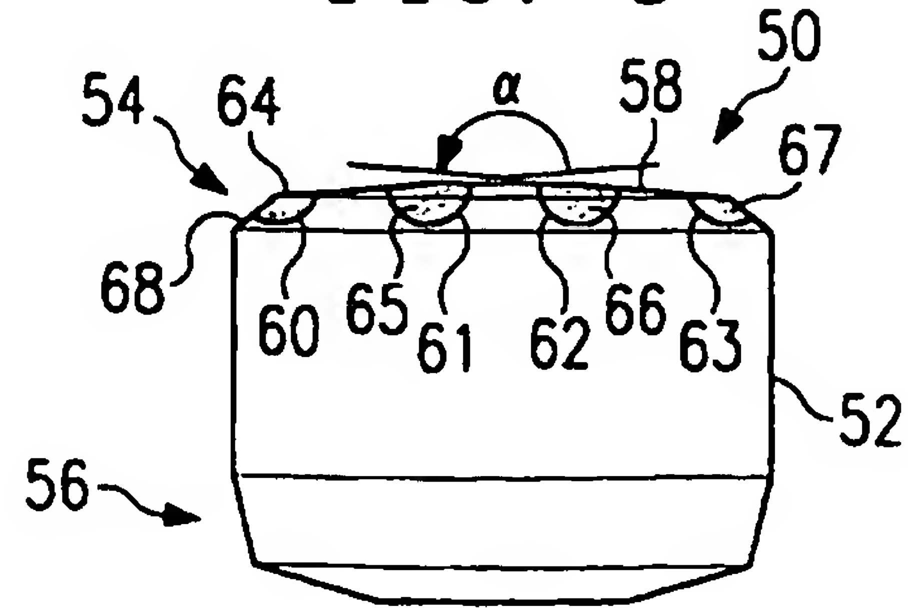


FIG. 6



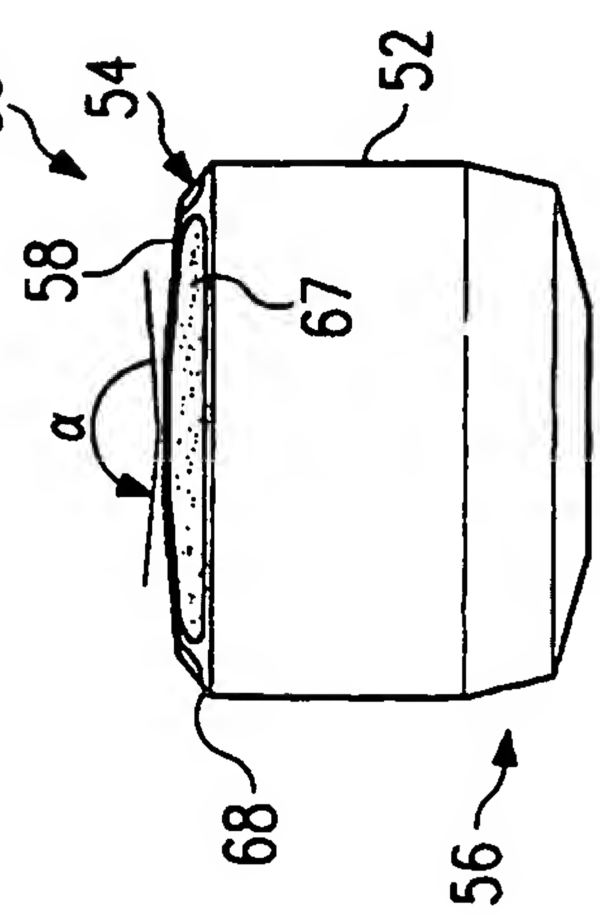


FIG. 7

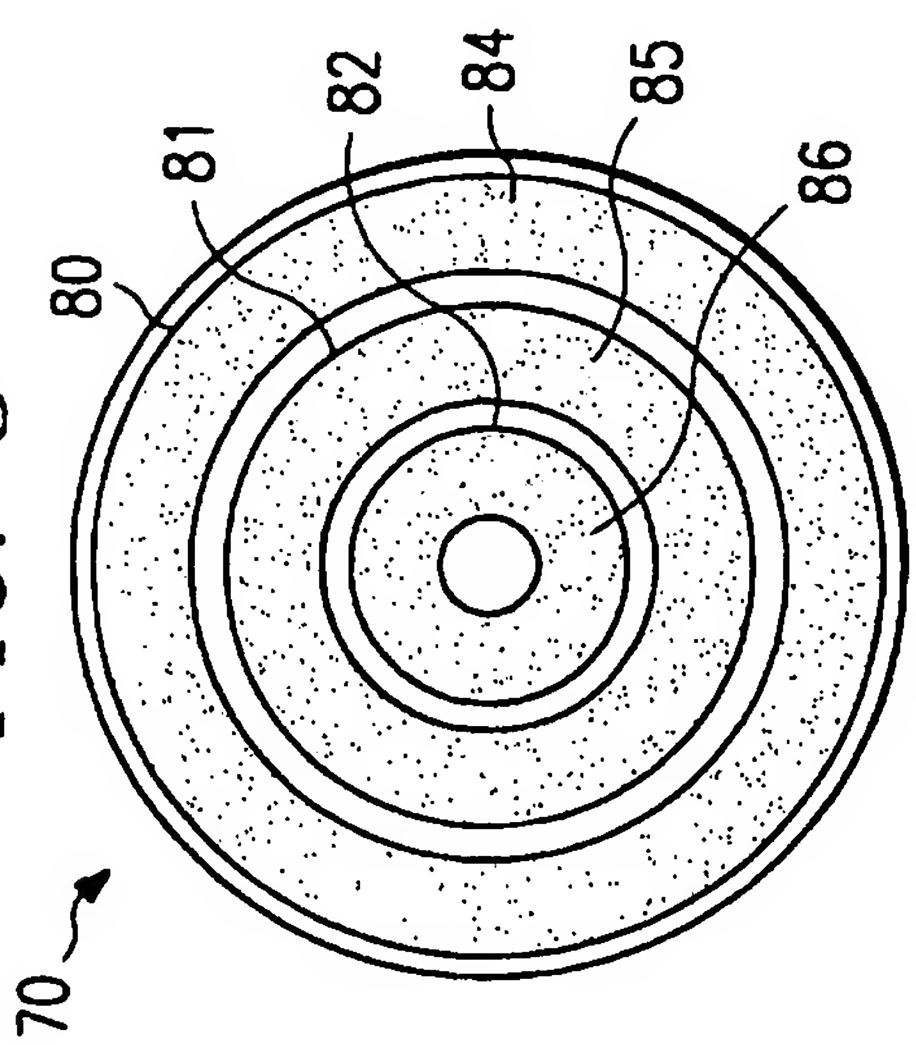


FIG. 8

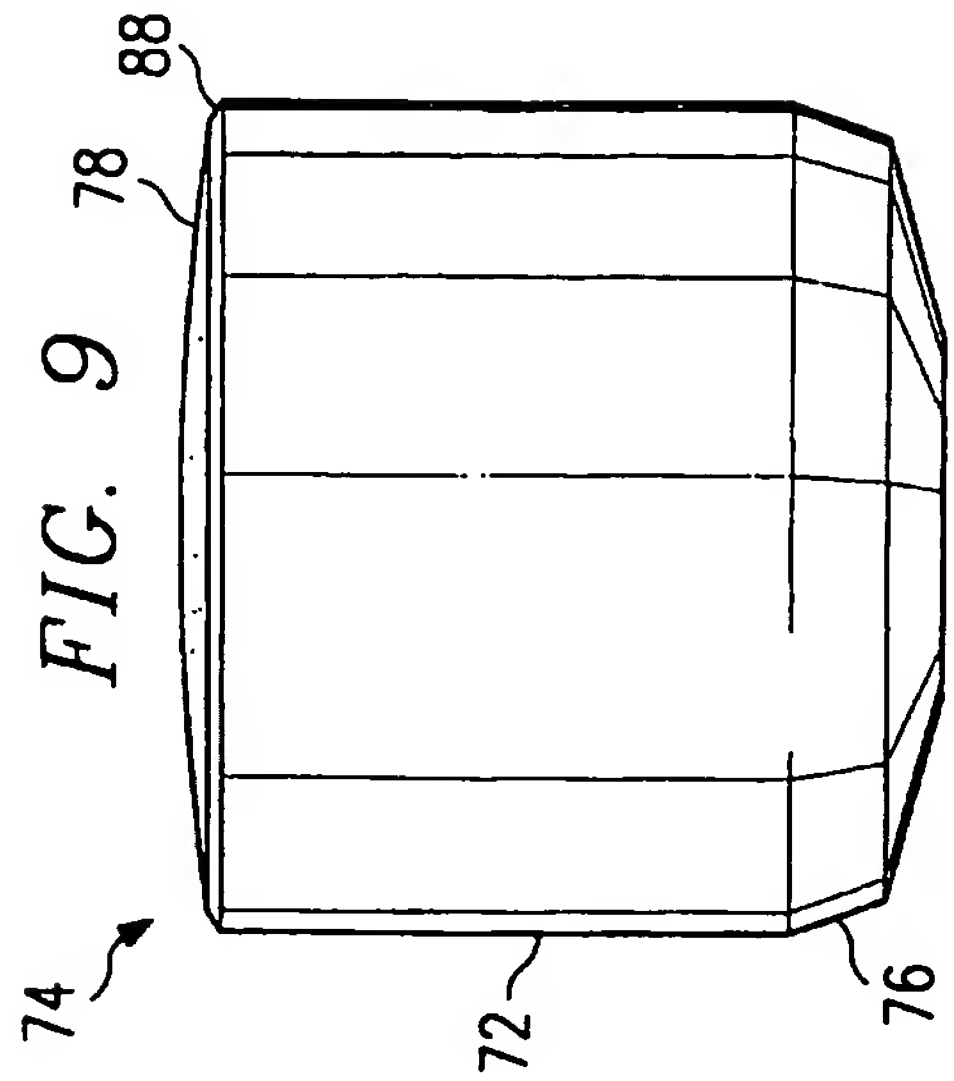


FIG. 9

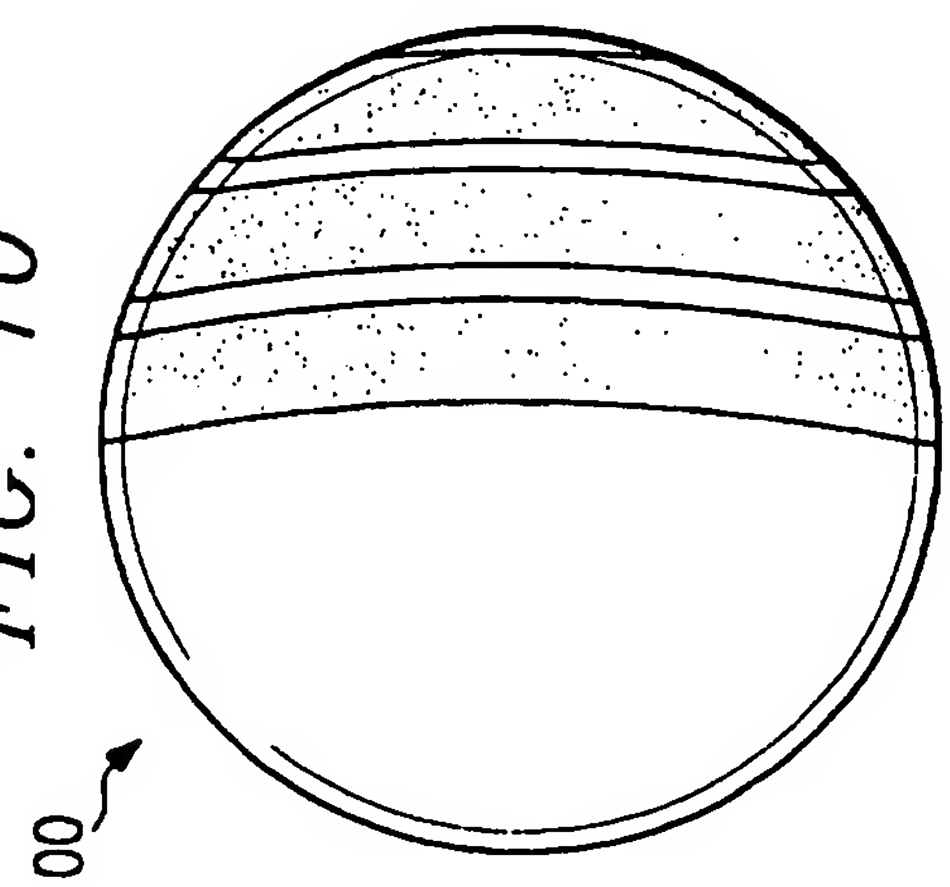


FIG. 10

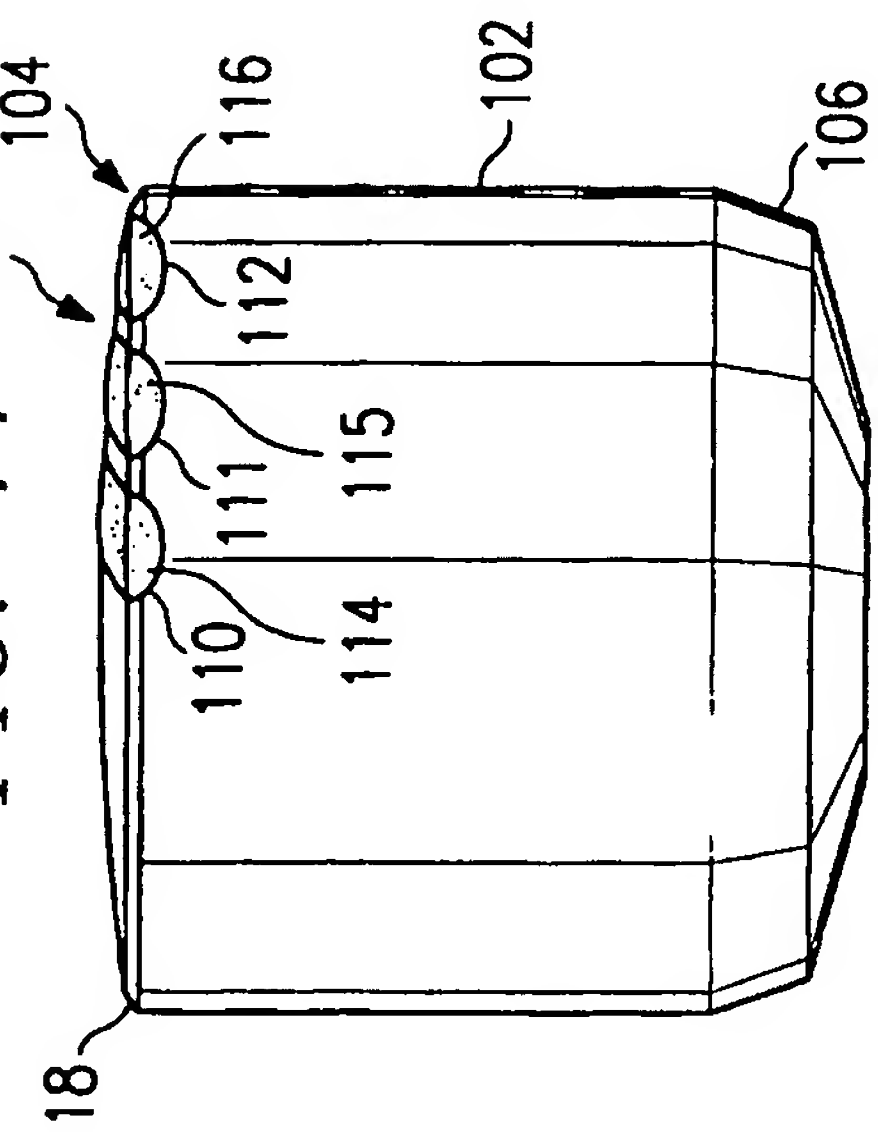


FIG. 11

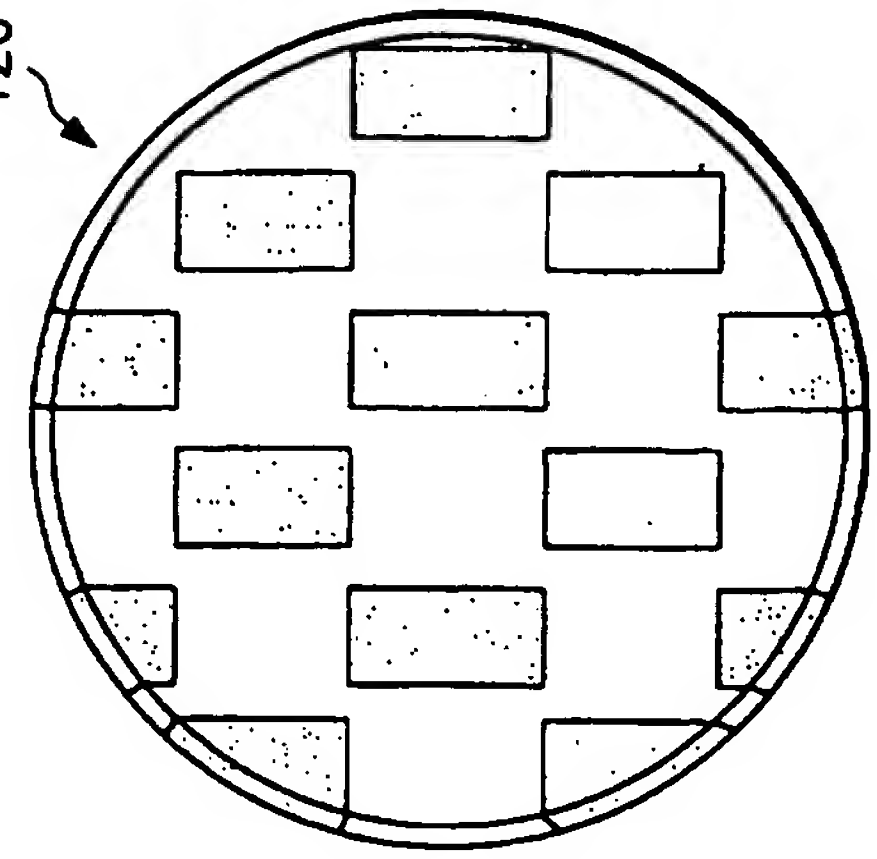


FIG. 12

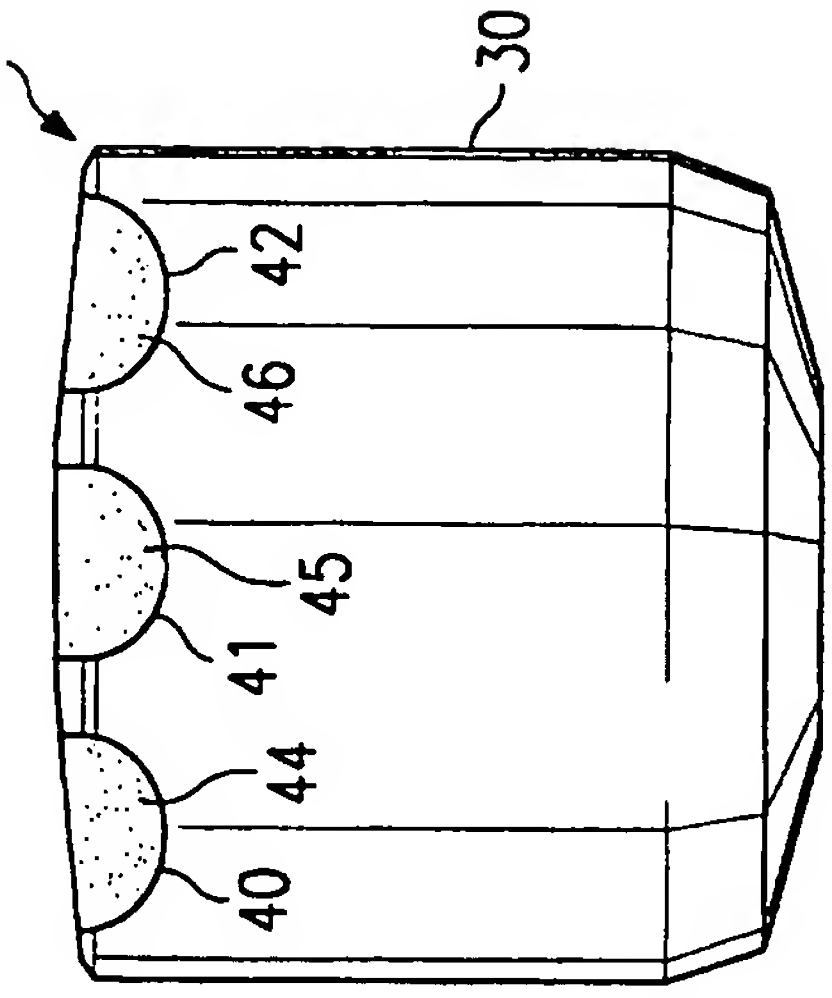


FIG. 15

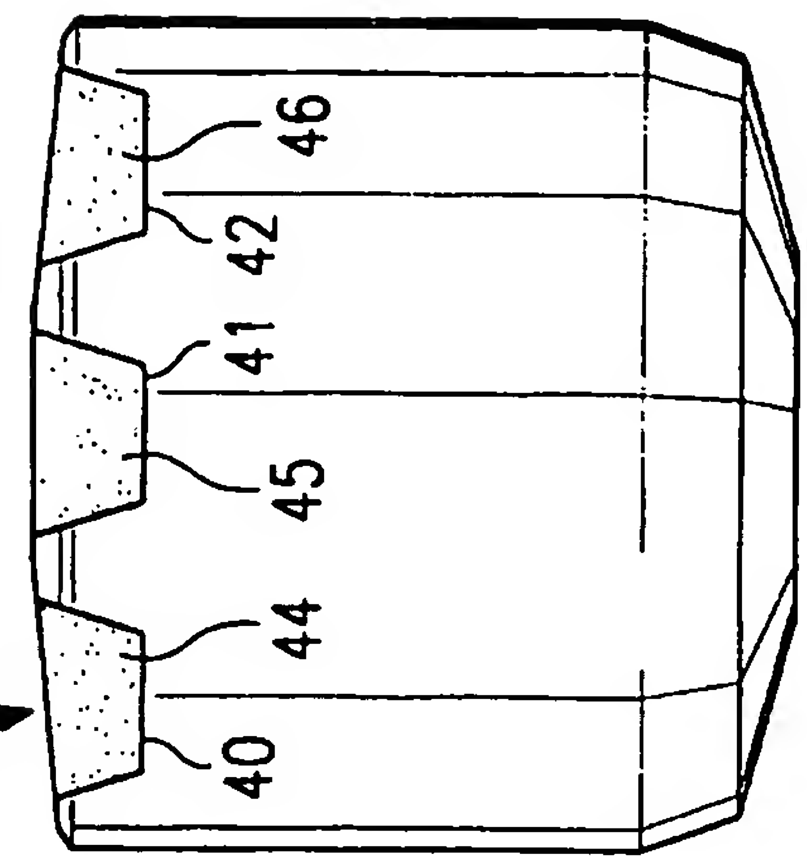


FIG. 18

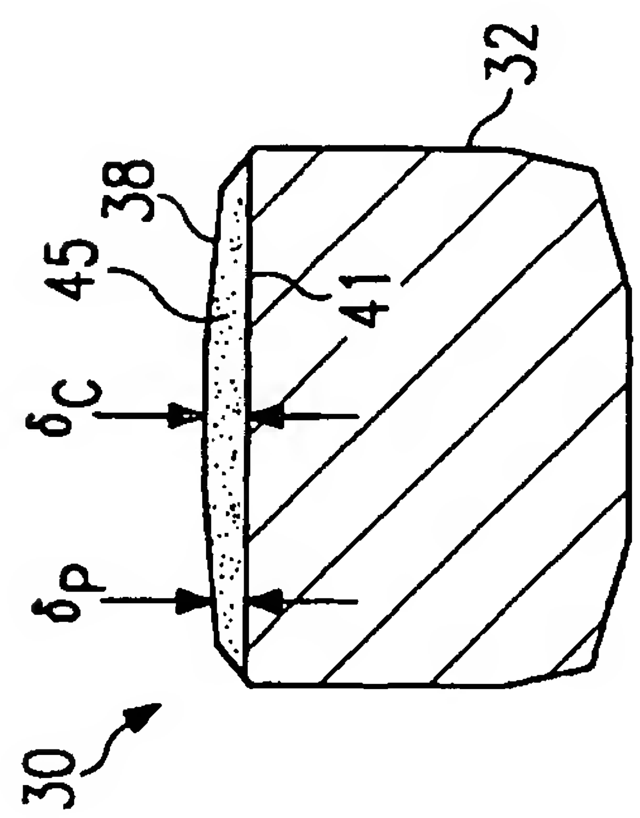


FIG. 14

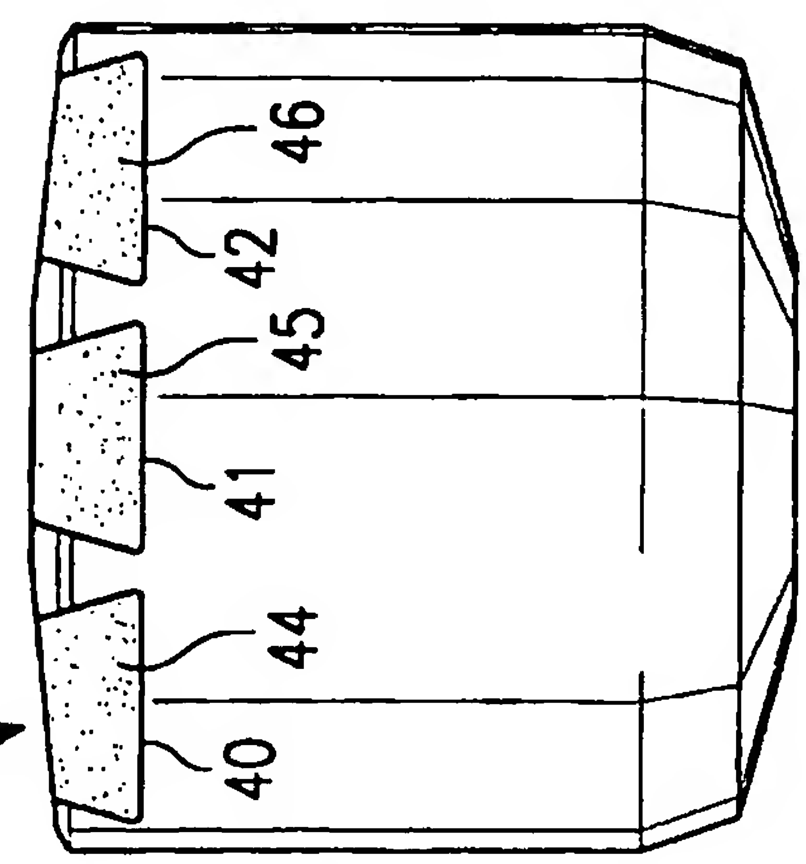


FIG. 17

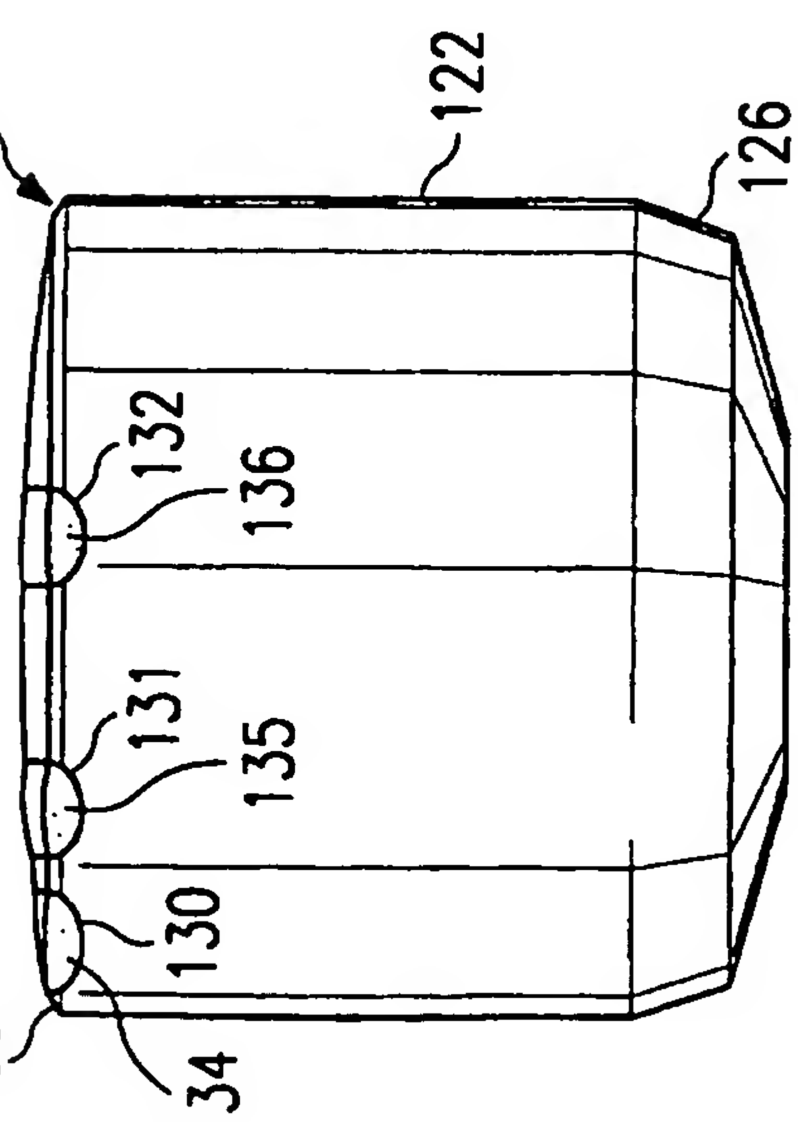


FIG. 13

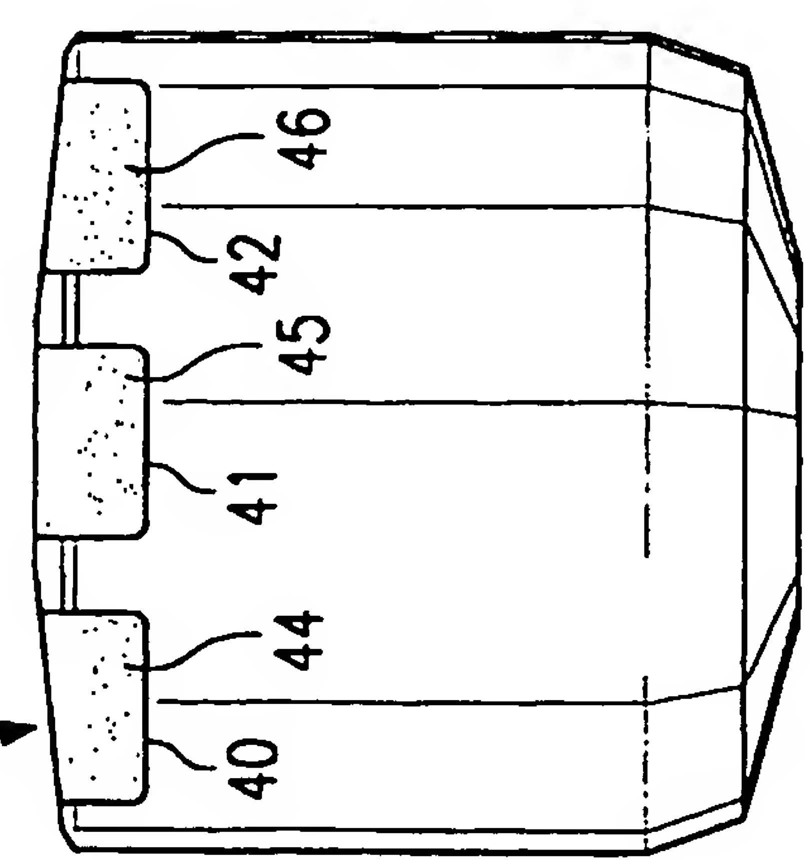


FIG. 16

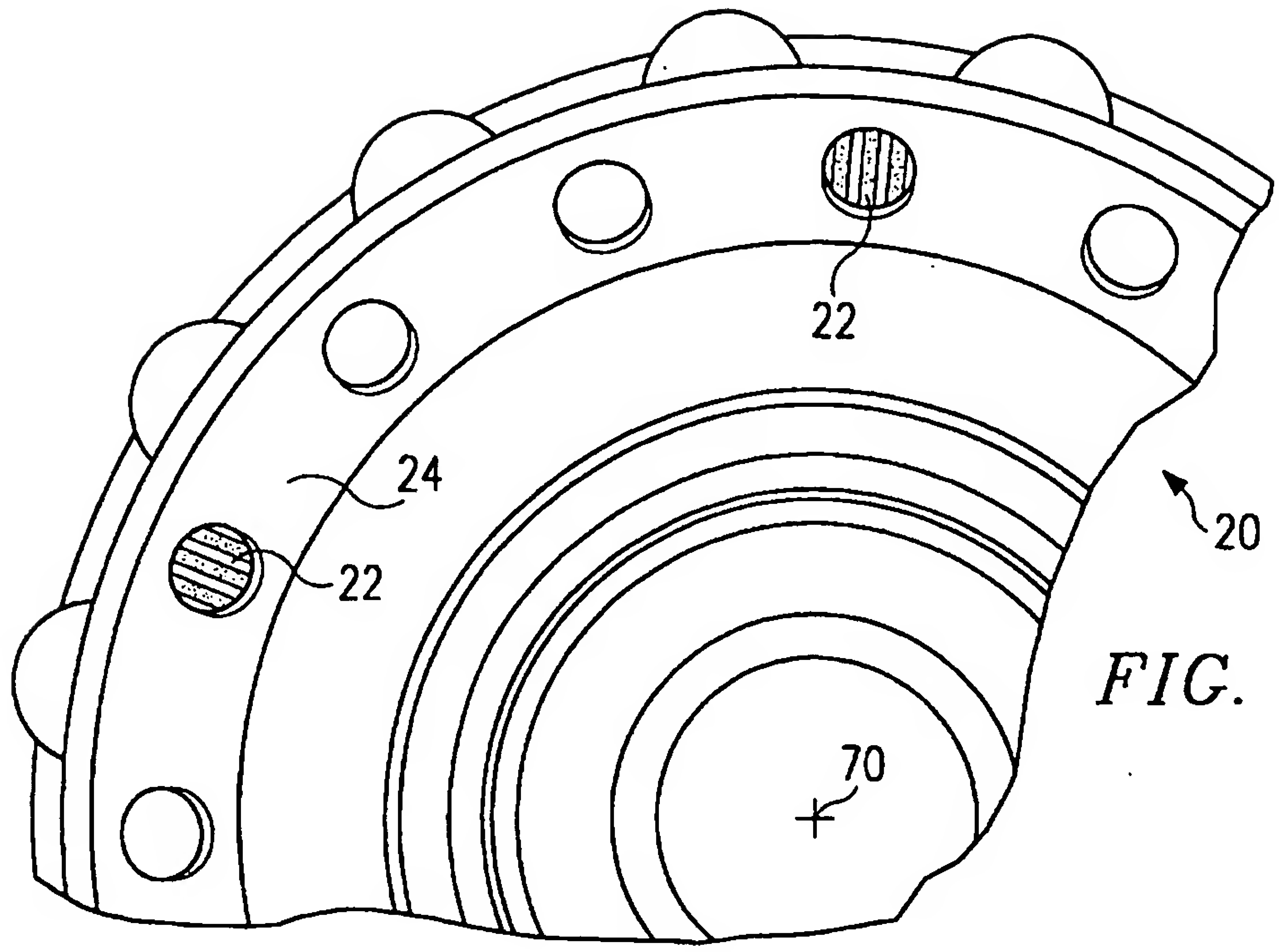


FIG. 19A

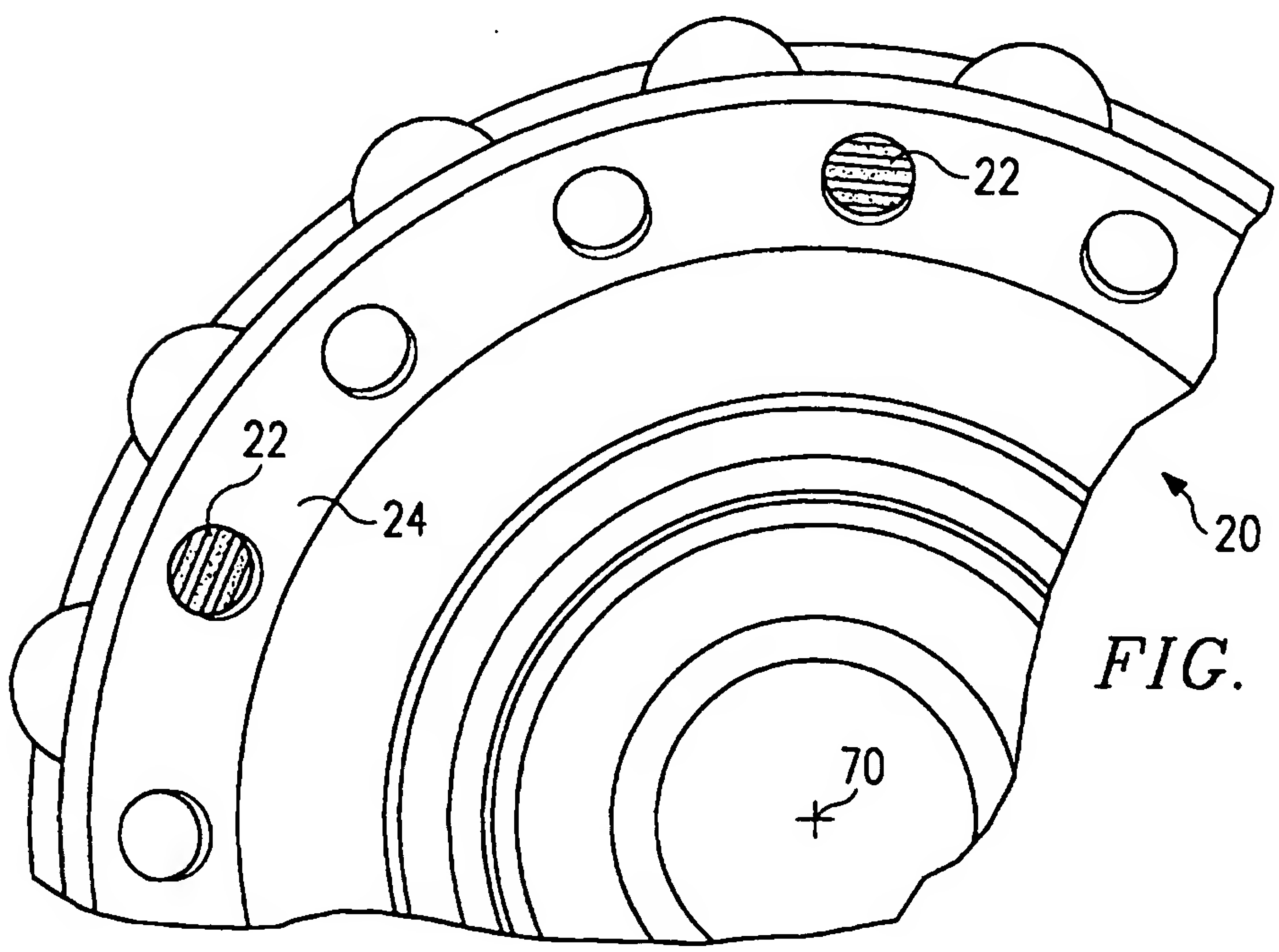


FIG. 19B

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/03812

A. CLASSIFICATION OF SUBJECT MATTER
IPC(6) :E21B 10/16, 10/50
US CL :175/374, 426
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED
Minimum documentation searched (classification system followed by classification symbols)
U.S. : 175/331, 374, 426, 428, 434; 51/307

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X ---- Y	GB 2138864 A (SUMITOMO METAL MINING COMPANY LIMITED) 31 October 1984 (31/10/84), page 1, lines 108-125.	1, 9-10, 12-13, 36, 38-41, 49, 50, 52, 53, 76, 78 --------- 7-8, 15-19, 25-29, 35, 37, 47, 48, 55-59, 65-69, 75, 77
Y	US 4,592,433 A (DENNIS) 03 June 1986 (03/06/86), column 3, lines 40-67.	7-8, 15-19, 25-29, 35, 37, 47, 48, 55-59, 65-69, 75, 77

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search
29 APRIL 1997

Date of mailing of the international search report
14 MAY 1997

Name and mailing address of the ISA/US
Commissioner of Patents and Trademarks
Box PCT
Washington, D.C. 20231
Facsimile No. (703) 305-3230

Authorized officer
DAVID J. BAGNELL
Telephone No. (703) 308-2151